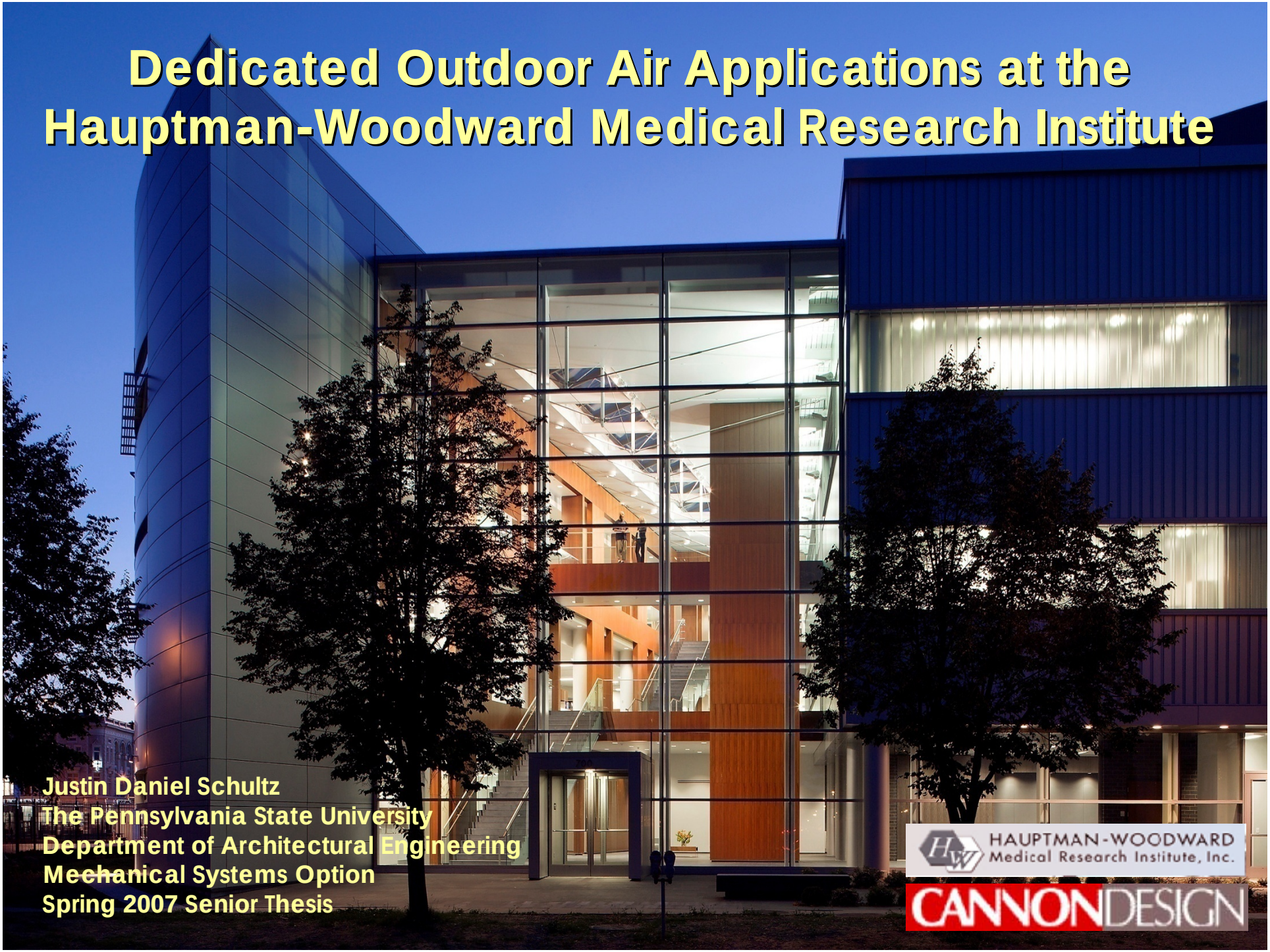
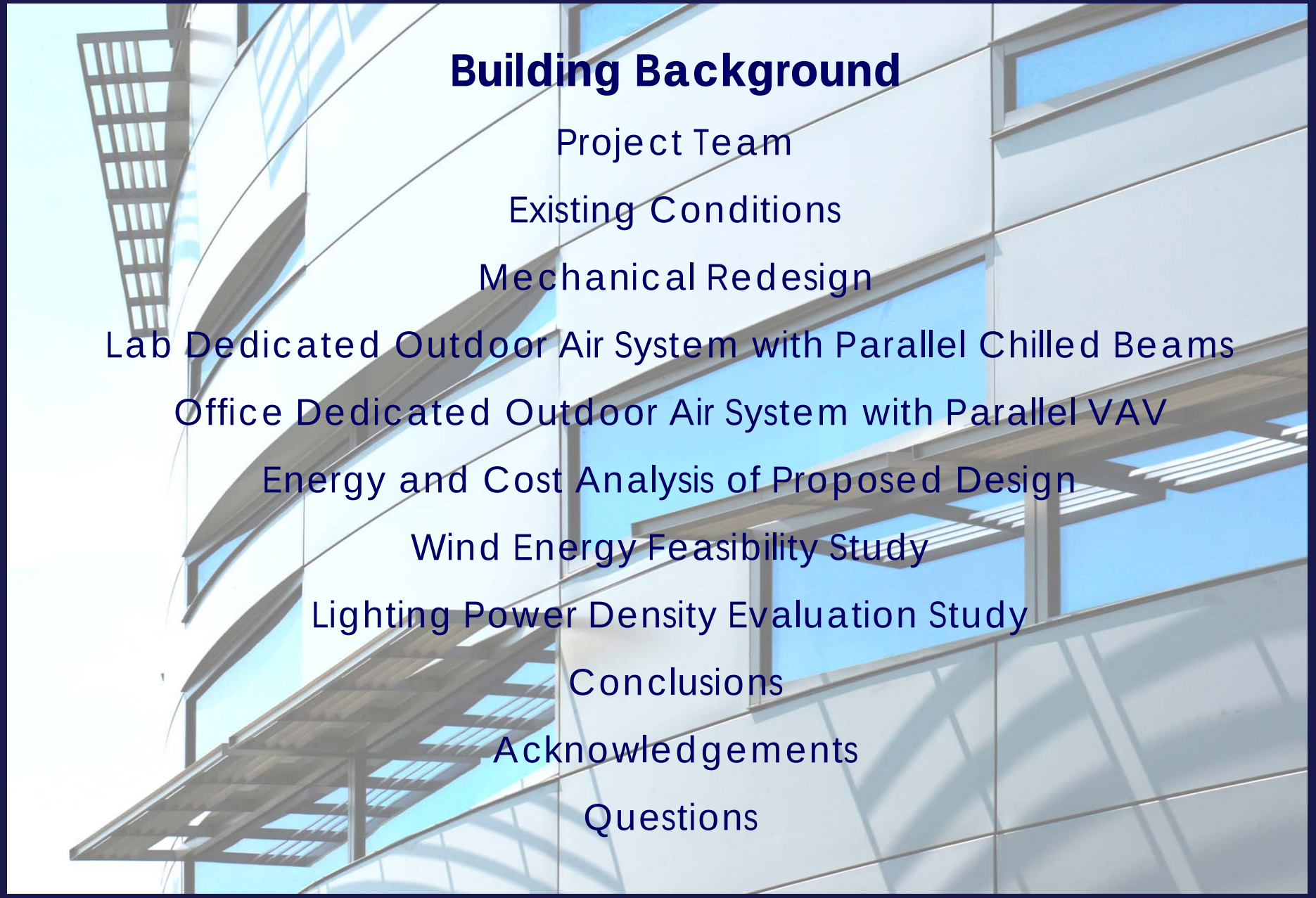
Dedicated Outdoor Air Applications at the Hauptman-Woodward Medical Research Institute



Justin Daniel Schultz
The Pennsylvania State University
Department of Architectural Engineering
Mechanical Systems Option
Spring 2007 Senior Thesis

HAUPTMAN-WOODWARD Medical Research Institute, Inc.

CANNONDESIGN



Building Background

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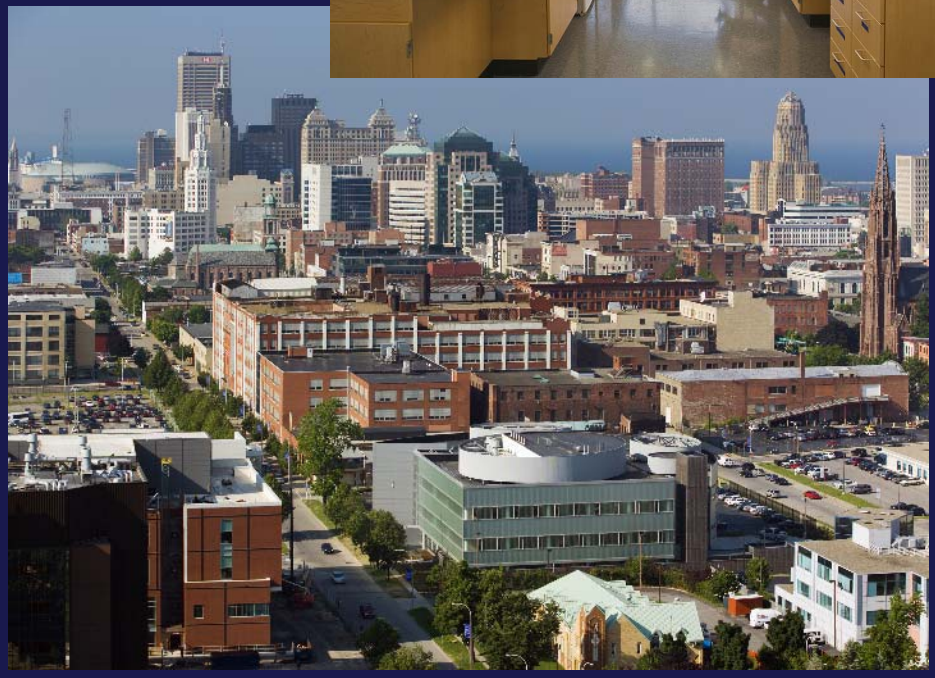
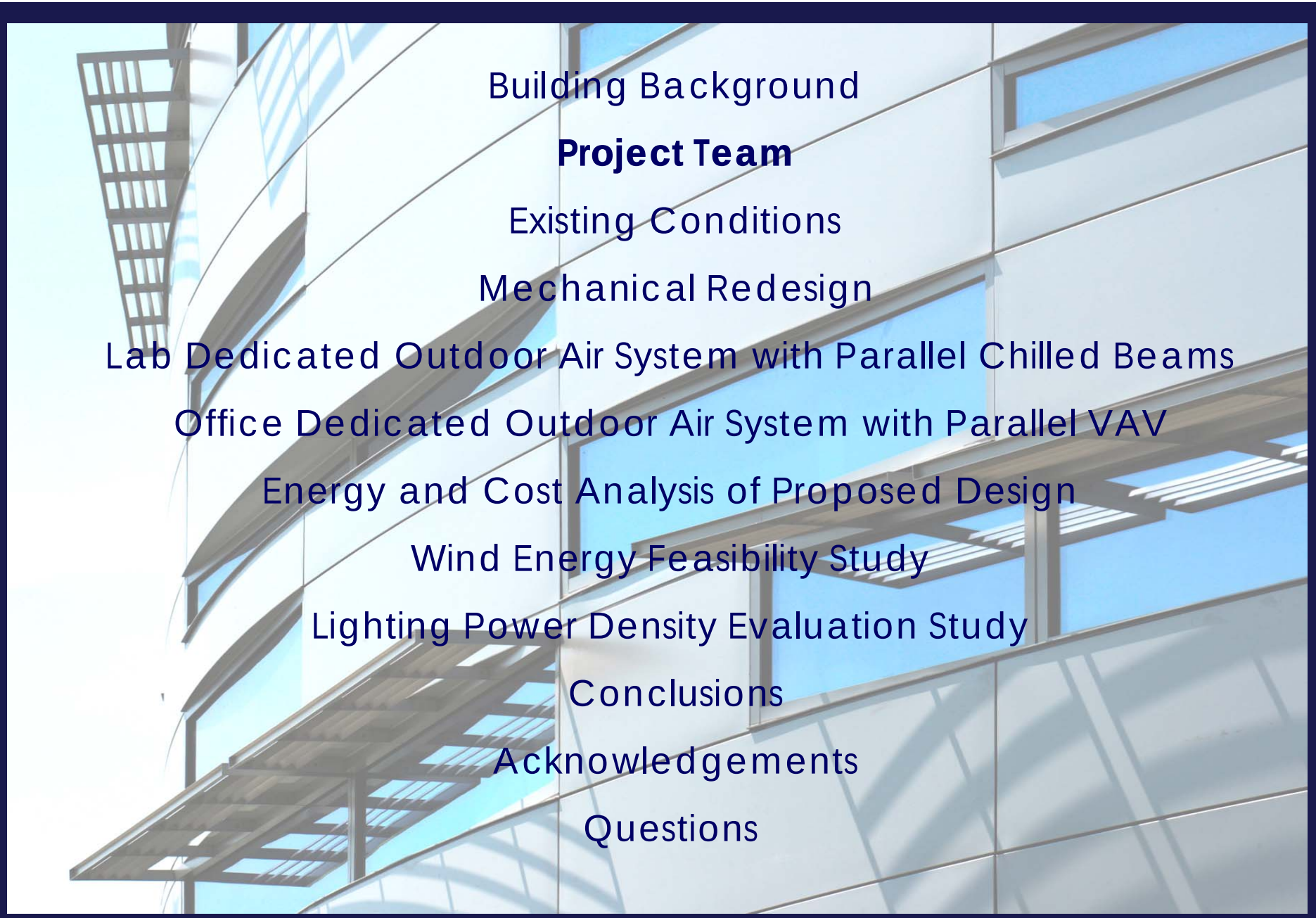
Building Background

General Information

- Biomedical Laboratory with mixed office/classroom space
- Location: Buffalo, NY
- Size: 73,000 ft^2
- Project Cost: $24,000,000
- Procurement Type: Cost-Plus Fee
- Project Completion: May 2005





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Project Team

Architect:

Merhdad Yazdani,

Yazdani Studio of Cannon Design
(Los Angeles, CA)

Architects and Engineers:

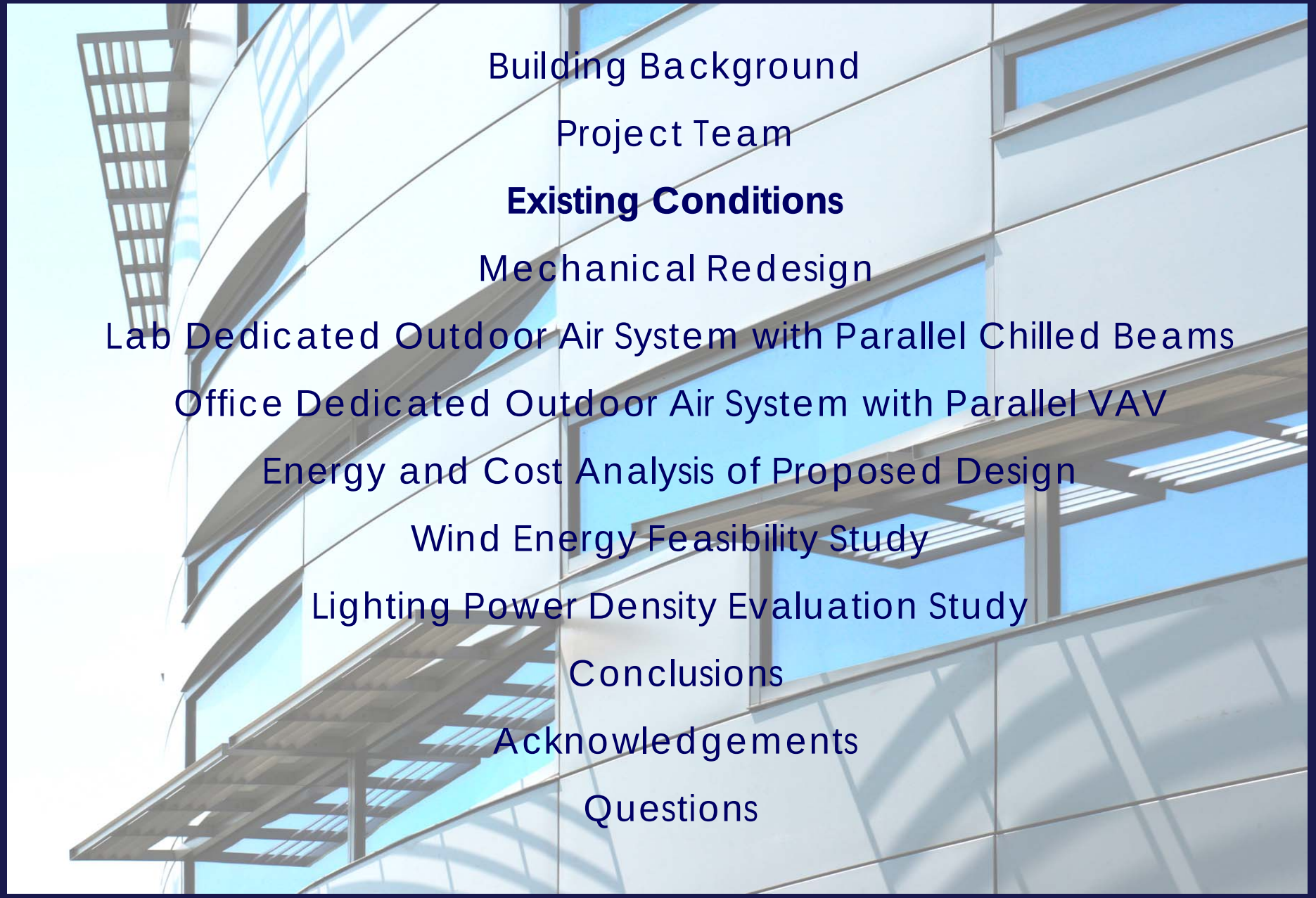
Cannon Design (Buffalo, NY)

Construction Manager:

Ciminelli Development

(Buffalo, NY)

Merhdad Yazdani discussing the building plan design at HWI



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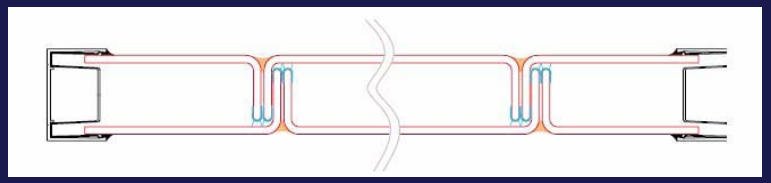
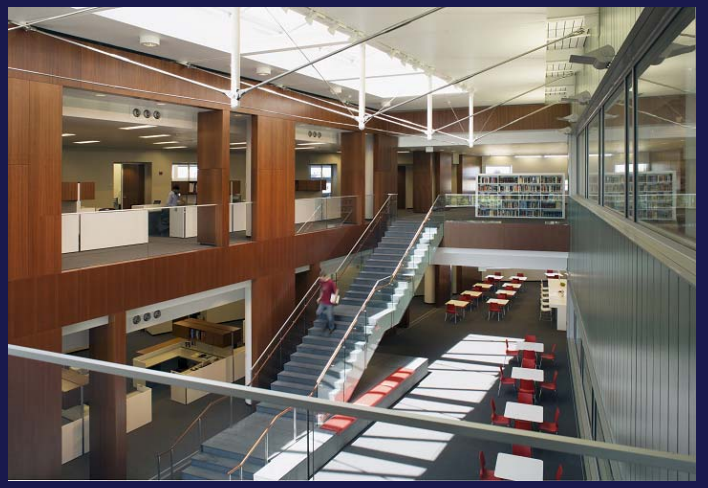
Existing Conditions

Architecture

- Aluminum Curtain Wall with varied casement windows and solar shading

- Laboratory Fritted Glass wall Assembly





- 3 story central atrium unifying building

Existing Conditions

Lighting/Electrical Systems

- 480/277V 3phase, 4 Wire Primary
- 120V and 277V Luminaries provide task and accent lighting
- 1.46 W/ft^2 Lighting Power Density
- 450kW/563kVA Fuel-Fired Emergency Generator

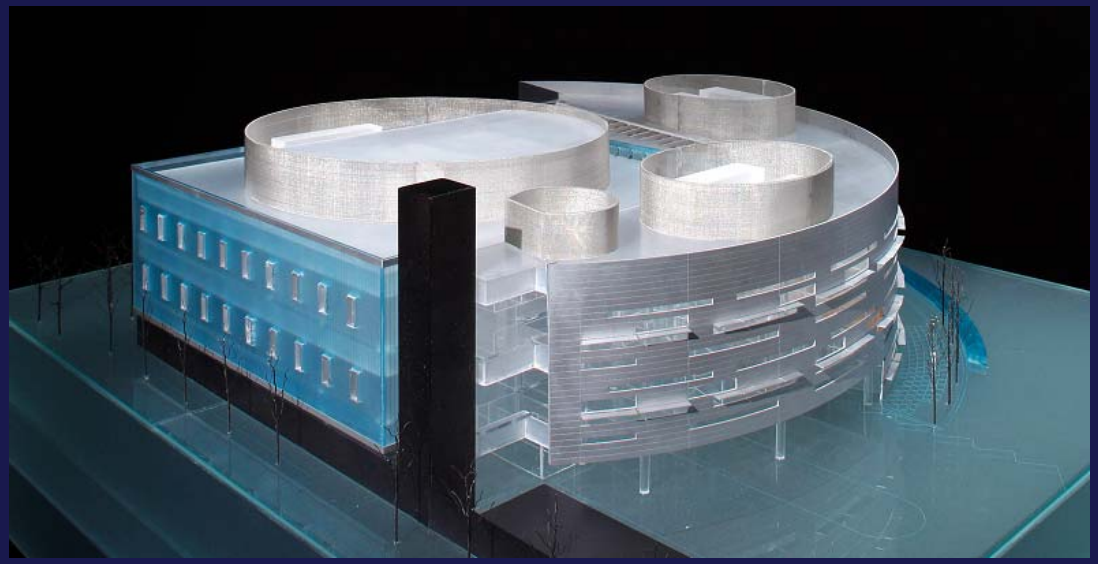
Structural System

- 5” Slab-On-Grade Construction
- 4’ poured concrete footings
- Structural Steel Building Skeleton
- Oversized members to provide rigidity
- King-Post Truss System in atrium provides roof and skylight support

Existing Conditions

Mechanical

- (2) DX Rooftop AHU's provide 42,000cfm to office
- (2) 100% Outdoor AHU's provide 58,000cfm to Lab
- (1) 300 Ton Air Cooled Screw Chiller for AHU Cooling Coils
- VAV Reheat for all Systems
- (6) 2,0000 MBH Hot Water Boilers for building heat
- Laboratory Run-Around Heat Recovery Loop



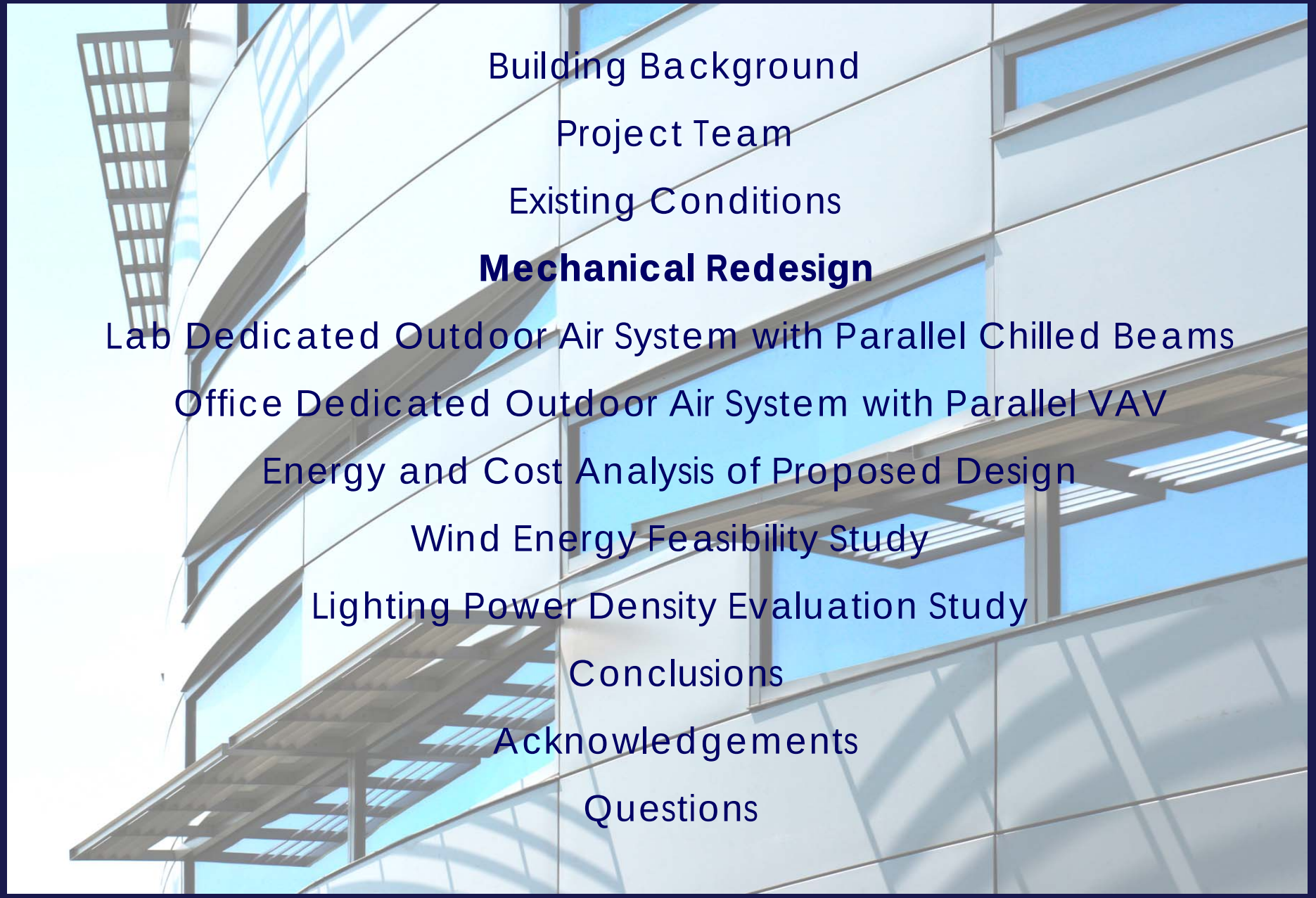
Existing Conditions

Mechanical (cont'd)

- Dedicated Laboratory Exhaust System for hood contaminant control
- Atrium Smoke Exhaust System with linked exhaust and makeup air fans

- Design Air Conditions

Indoor Design Conditions				
	Summer		Winter	
	Occupied	Unoccupied	Occupied	Unoccupied
DBT (^{O}F)	72	82	70	65
% RH	50	50	50	50



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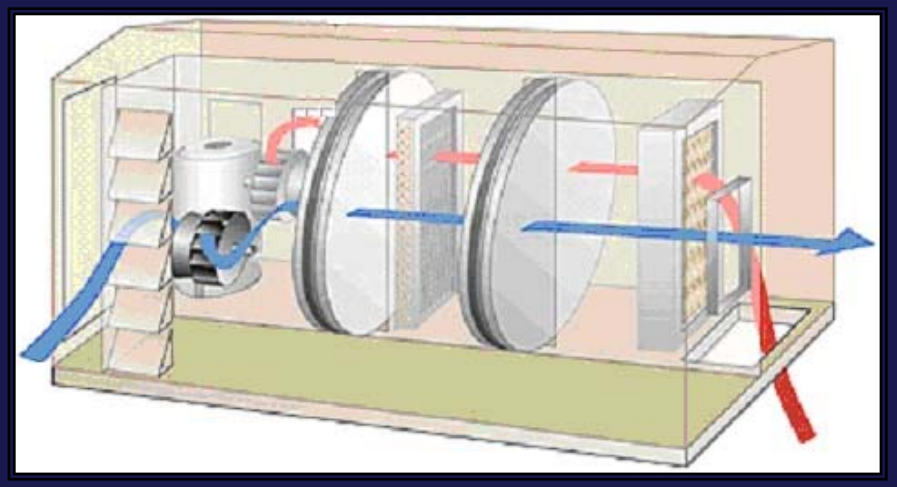
Proposed Redesign

Dedicated Outdoor Air Systems

- Replace DX Units with DOAS System/Parallel VAV
- Replace 100% Outdoor Air Units with DOAS/Parallel Chilled Beams



Justification

- Reduced Required Mechanical Space
- Reduced First Cost
- Reduced Annual Utility Costs
- Improved Indoor Air Quality compared to DX Units
- Desiccant Wheels proven reliable in Laboratory Applications

Proposed Redesign

Parallel Systems

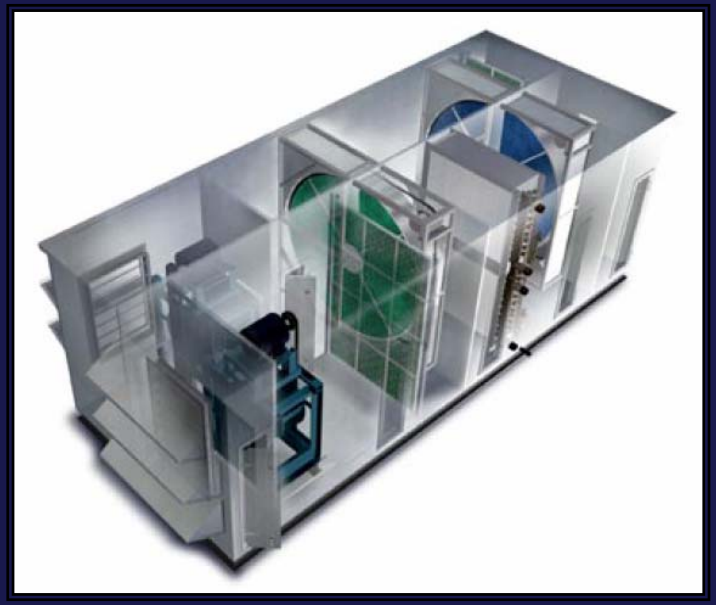
- VAV on Office Side
- Chilled Beams on Lab Side

Laboratory DOAS AHU

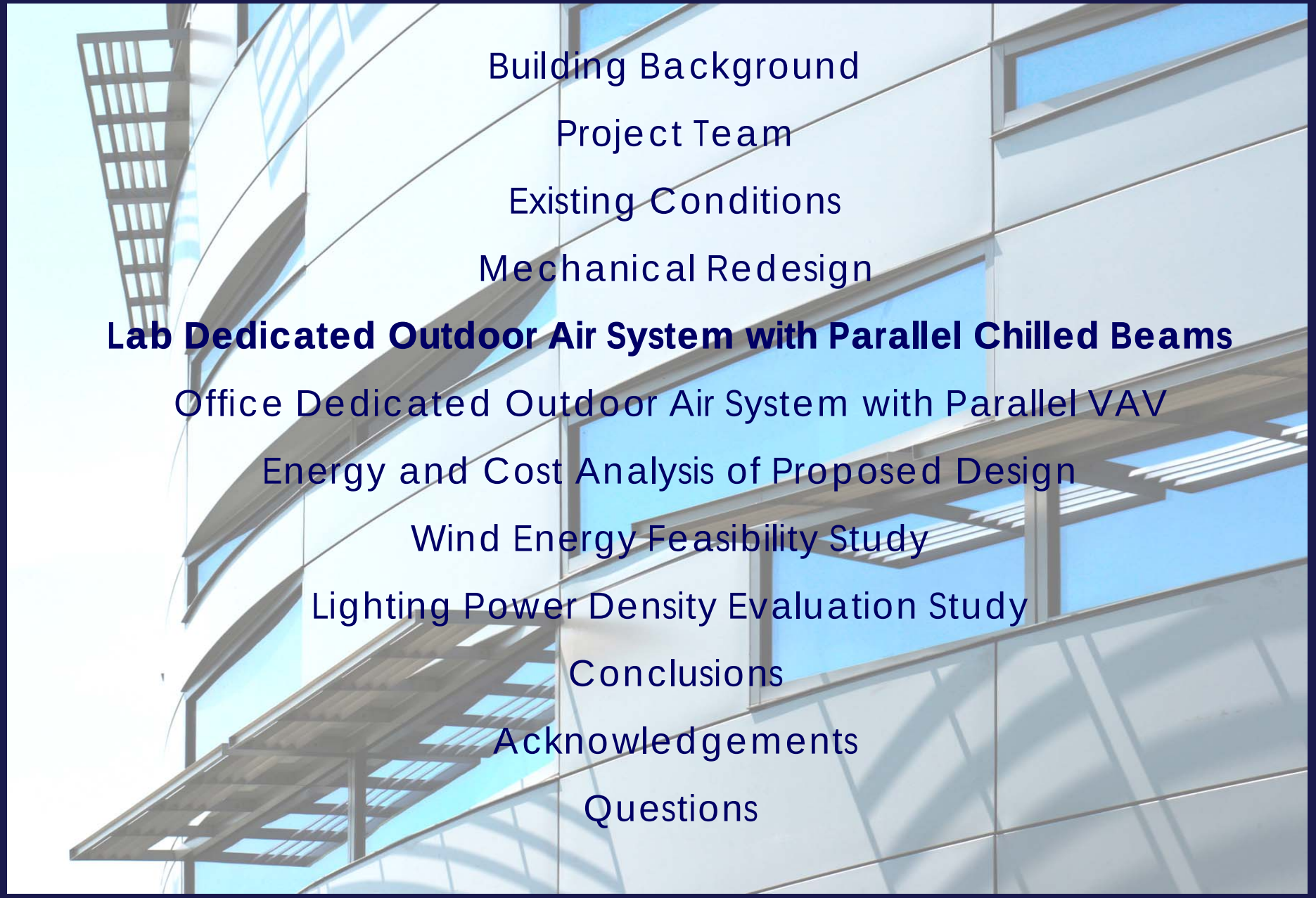
- 25 Ton Cooling Coil
- Desiccant Wheel Only
- 6500 cfm ventilation requirement

Office DOAS AHU

- 30 Ton Cooling Coil
- Enthalpy Wheel and Sensible Wheel
- 10,500 cfm ventilation requirement



SEMCO Dedicated Outdoor Air Handling Unit with Enthalpy and Sensible Wheels



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Mechanical Option

The Hauptman-Woodward
Medical Research Institute

Spring 2007 Senior Thesis

Laboratory System

- Exposed Ceilings in lab can easily accommodate chilled beams

DOAS Cooling Capacity:

Q_{SA} = 1.08 x 6500 cfm x (72 ^{O}F - 62 ^{O}F)

Q_{SA} = **70,200 Btu/hr**

Parallel System Cooling Capacity

$Q_{PARALLEL} = Q_{SENSIBLE} - Q_{SA}$

$Q_{SENSIBLE}$ = 643,000 Btu/hr

$Q_{PARALLEL}$ = 643,000 - 70,200 Btu/hr **=** 572,800 Btuh

572,800 Btuh x 1W/3.4112 Btuh = **167,878W**

Total Beam Length: 167,878 W / 510 W/m = 329.2 m

# of Beams = Total Length / Spec Beam Length

=329.2 m / 1.21 m

= 272 Chilled Beams required

Brand	Halton
Model	CPA-130/100-615
Cooling Capacity	510 [W/m]
Room Temp	72^{o}F (22^{o}C)
EWT	62^{o}F (17^{o}C)
ΔT	5^{o}C
Length	1122 [mm]
Width	615 [mm]
Height	80 [mm]

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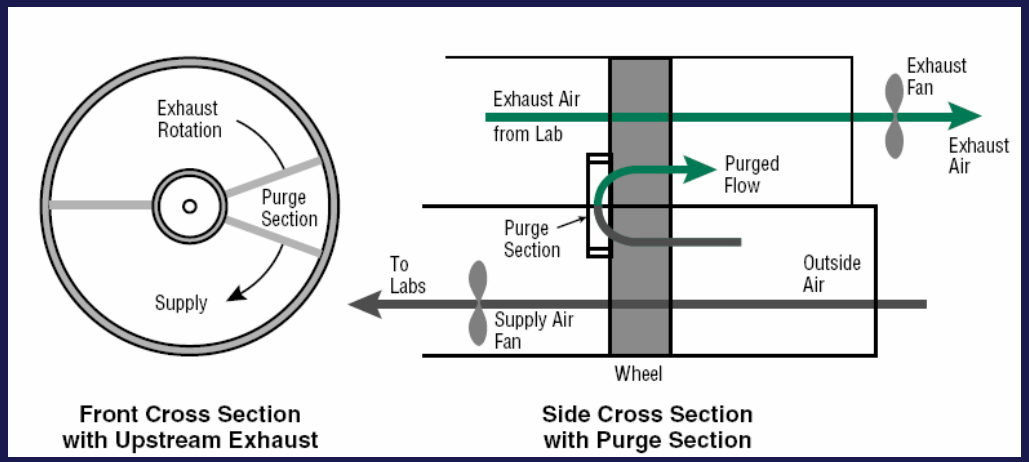
Laboratory System

- Drastic reduction in supply air as compared to 100% outdoor air system

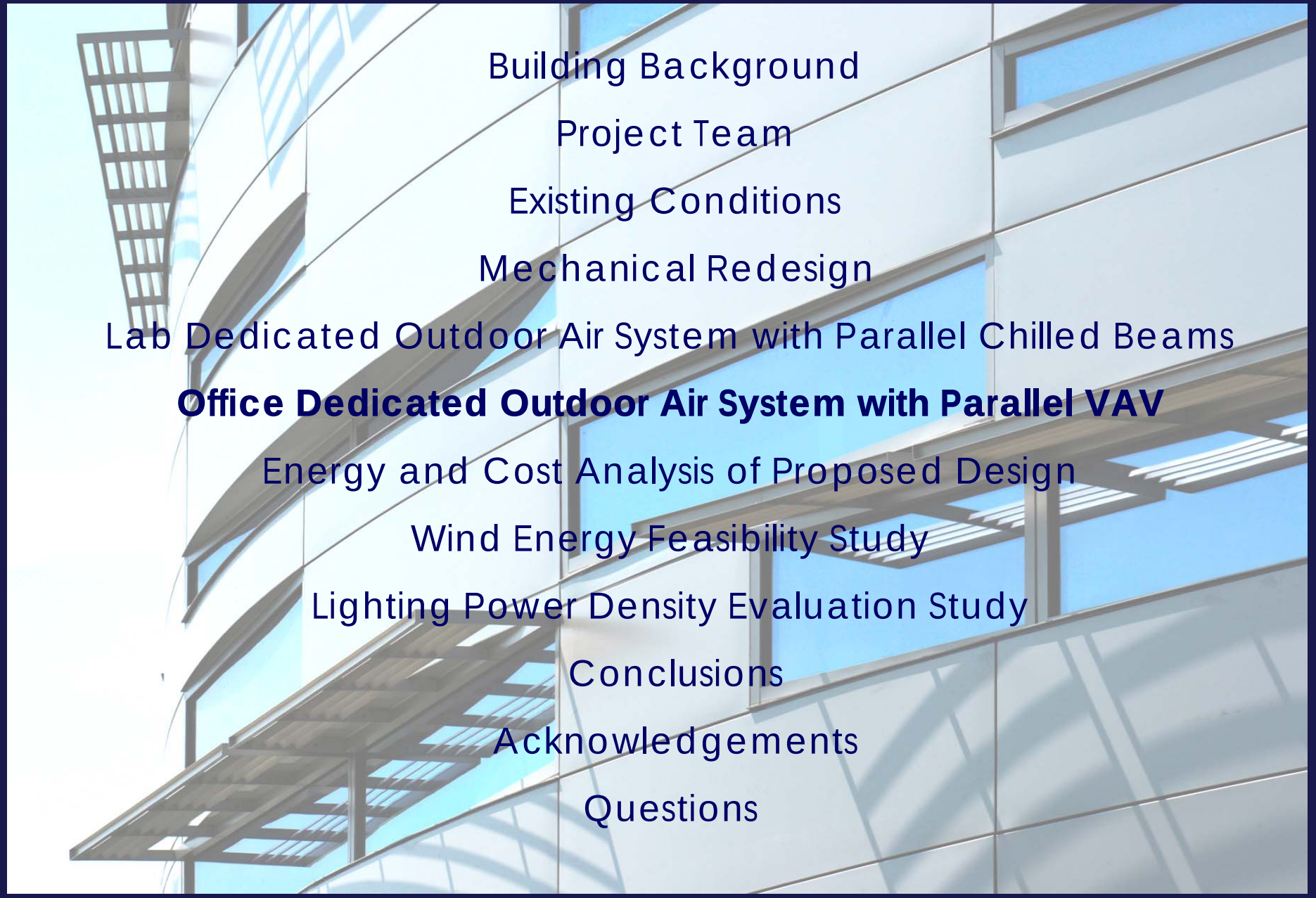
System	Existing SA (cfm)	Redesign SA (cfm)	Reduction (%)
AHU-1,2	58,000	9,400	83.8%



Contamination Issues?

- Wheel Purge section
- 3Å Molecular Sieve Desiccant provides "selective absorption"

- Johns Hopkins Ross Research Laboratory Case Study



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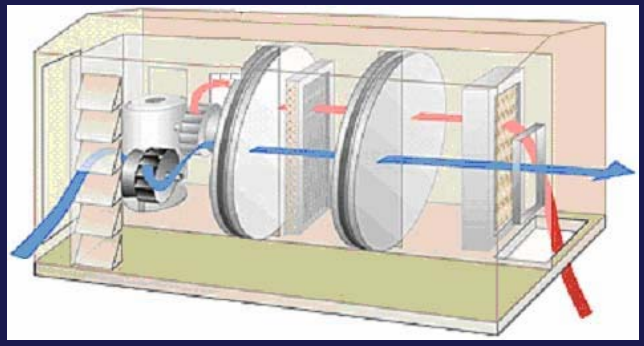
Office System

DOAS with Parallel VAV

- Convert Existing DX Systems to DOAS with Parallel VAV?

Required Supply air by Parallel VAV System based on Load

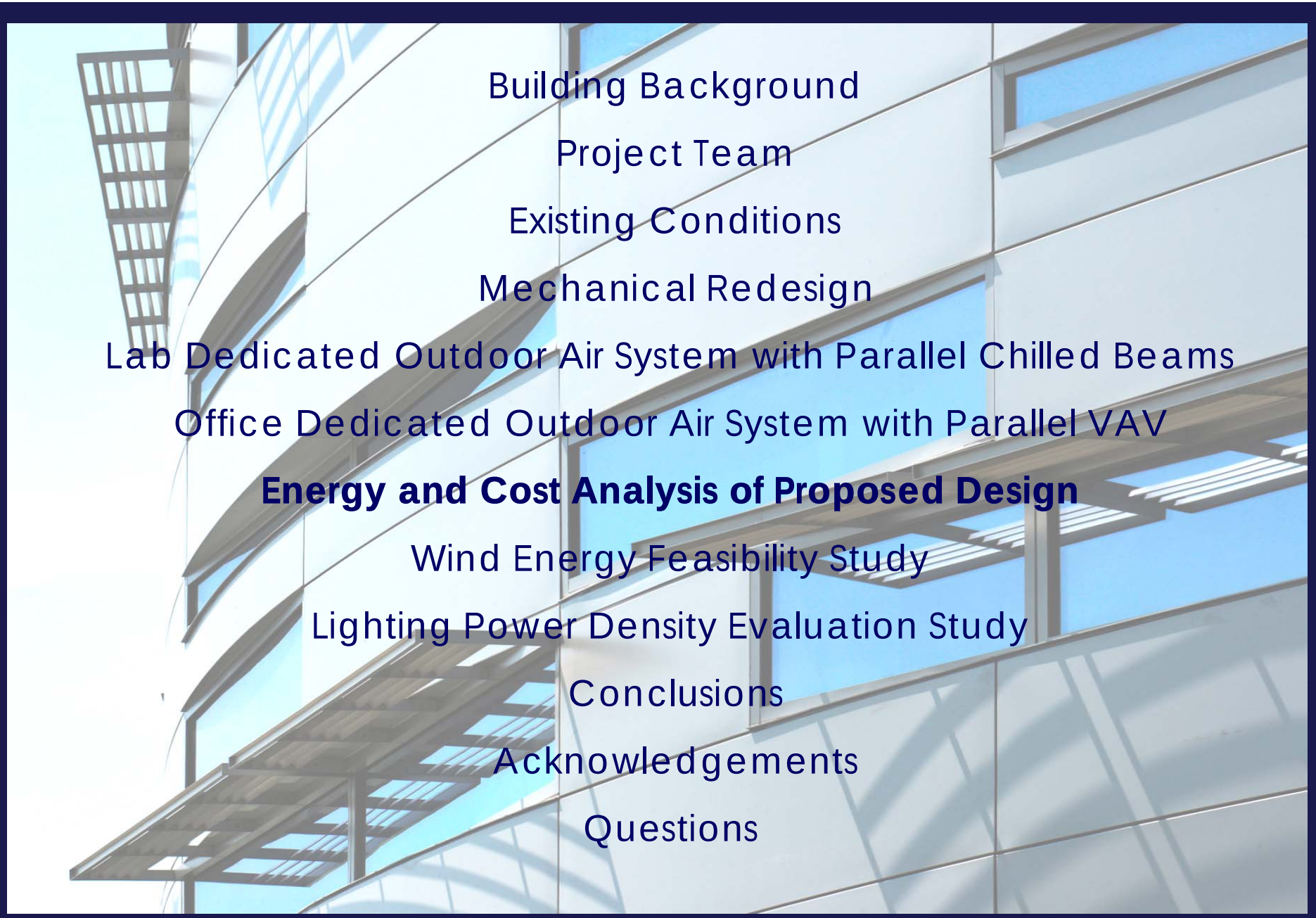
$$CFM_S = \frac{Q_S}{1.08 \times (T_{RA} - T_{SA})} = \frac{690,530 \text{ btu/hr}}{1.08 \times (72^{\circ}F - 55^{\circ}F)} = 37,528 \text{ cfm}$$



Reduction of Parallel Systems

- 12% reduction in supply air with DOAS/Parallel VAV compared to DX Rooftop Units

System	Existing SA (cfm)	Redesign SA (cfm)	Reduction (%)
RTU-1	14,175	12,500	11.8%
RTU-2	28,300	25,000	11.7%
Total	42,475	37,528	11.6%



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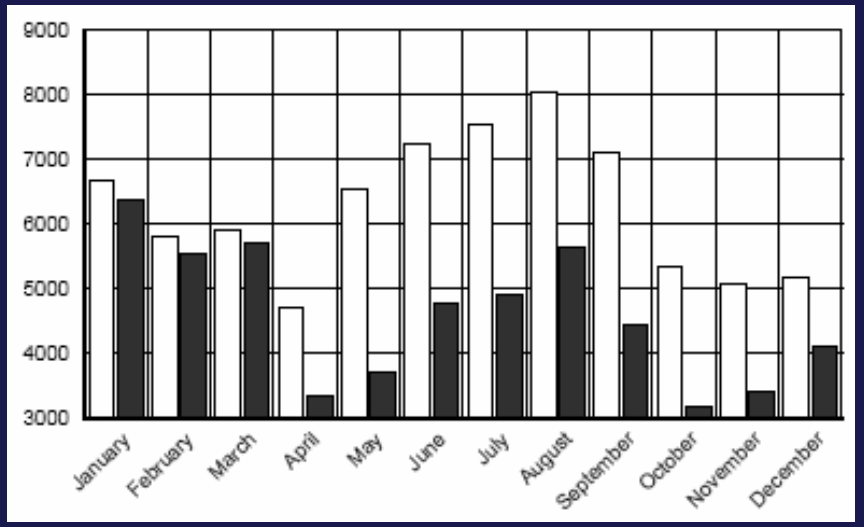
Annual Energy Reduction

- Trane TRACE-700 Energy Analysis

	Original Design	Proposed Design	Savings	%
Cost ($/yr)	75,166	55,069	20,097	26.74%
Consumption (kWh/yr)	2,116,058	1,581,585	534,473	25.26%

- Dedicated Outdoor Air Systems Reduce Load by approximately 25%.

- Reduced Life Cycle Cost of approximately 16% over 20 years with 5% inflation.

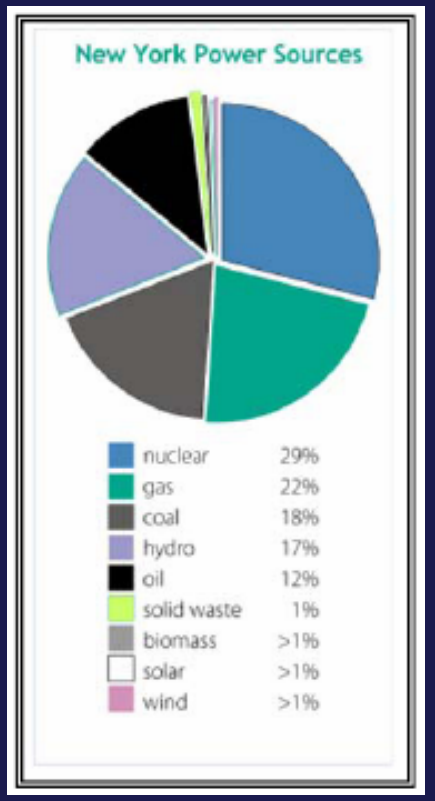


Emissions Reduction

- New York State Requires that 25% of generated power come from renewable sources by 2013.

	kWh	lbm Particulates	lbm SO_2	lbm Nox	lbm CO_2
Base	2,107,705	13,658	104,818	188,640	86,368,271
Redesign	1,859,199	12,048	92,460	166,399	76,185,141
% Reduction	11.79%	11.79%	11.79%	11.79%	11.79%

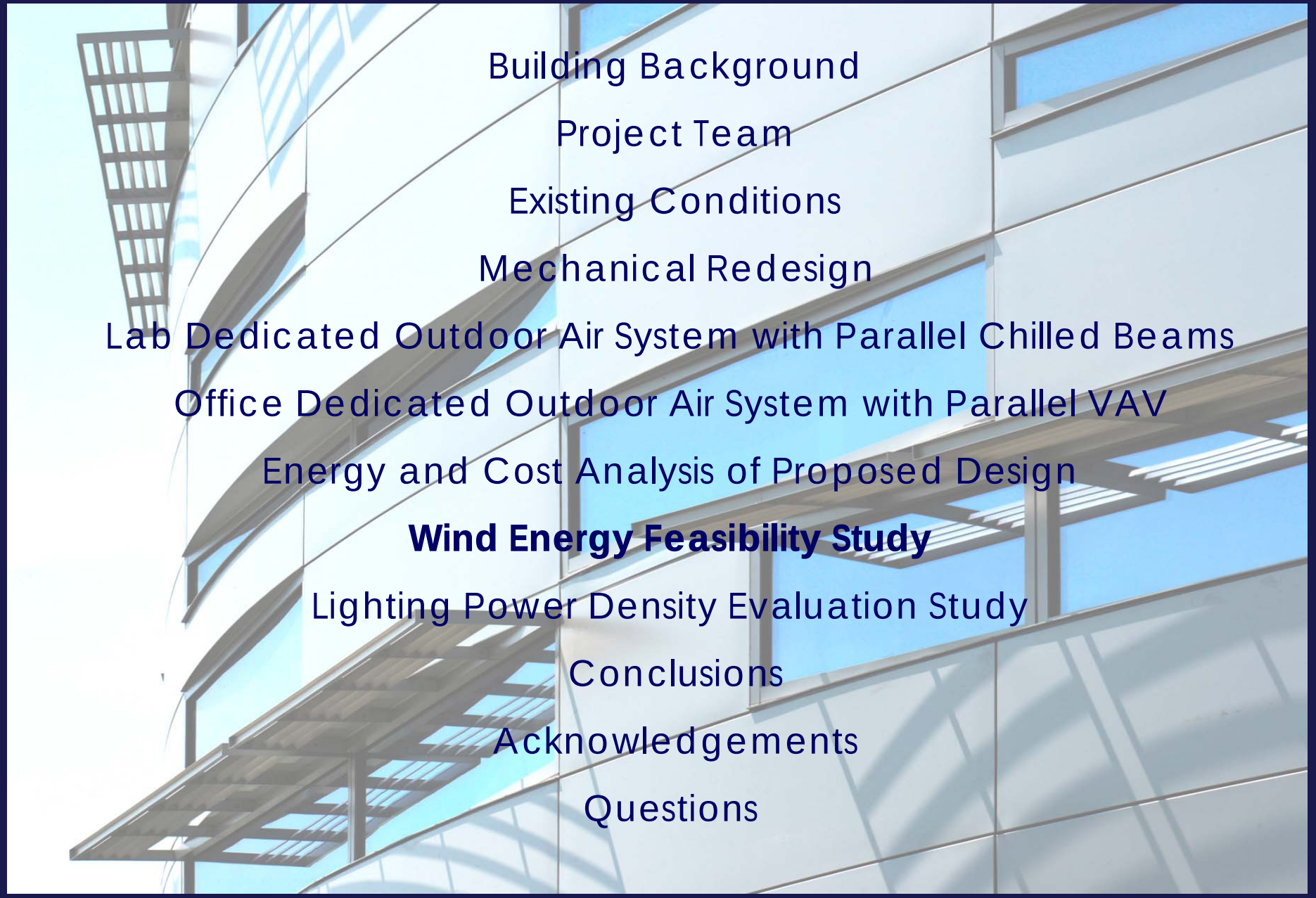
- Proposed redesign reduces emissions by approximately 12%.



First Cost Reduction

- R.S. Means Analysis
- The proposed system provided a reduced cost of $248,173 as compared to the existing system

	Existing System	Proposed DOAS Systems
Chiller [tons]	300	150
Boilers [mbh]	10,200	5100
AHU's	$154,500	$72,025
Chiller	$163,500	$97,500
Pumps (Primary)	$10,850	$5,150
Boilers	$21,000	$10,500
Pumps (Boiler)	$30,900	$15,450
Parallel Systems		
VAV	$137,770	$98,070
Chilled Beams		$187,000
Pumps (Parallel)		$5,150
Piping (Parallel)		$7,500
Ductwork	$304,000	$76,000
Totals:	$822,520	$574,345



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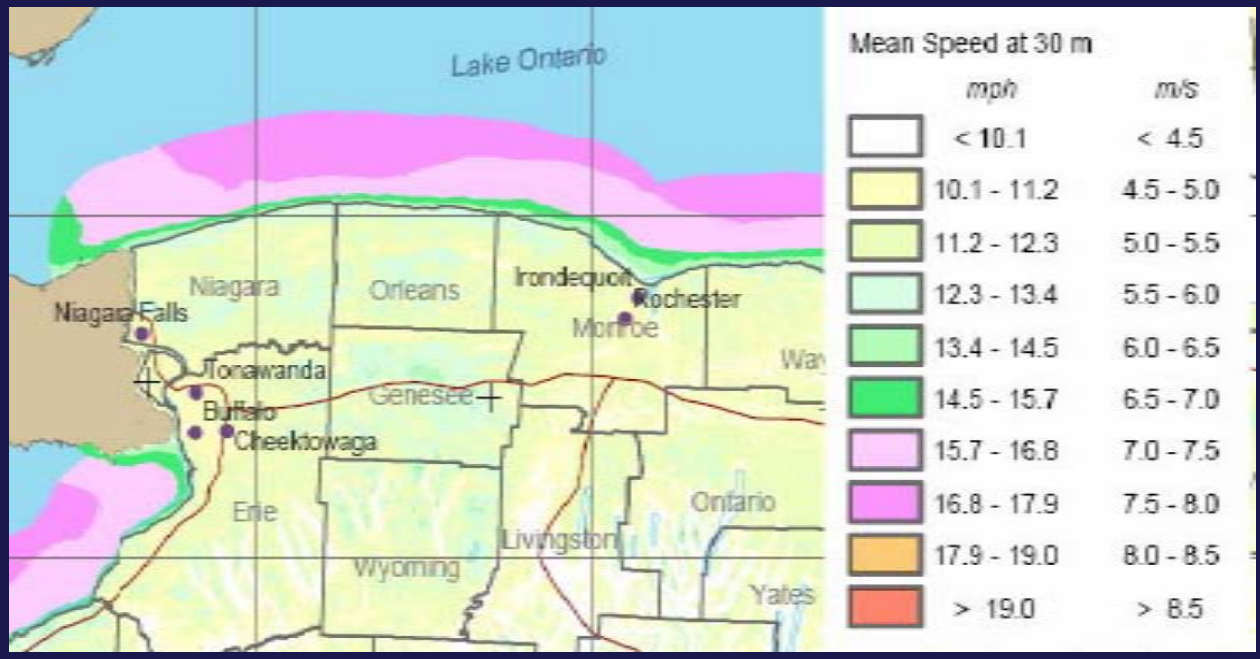
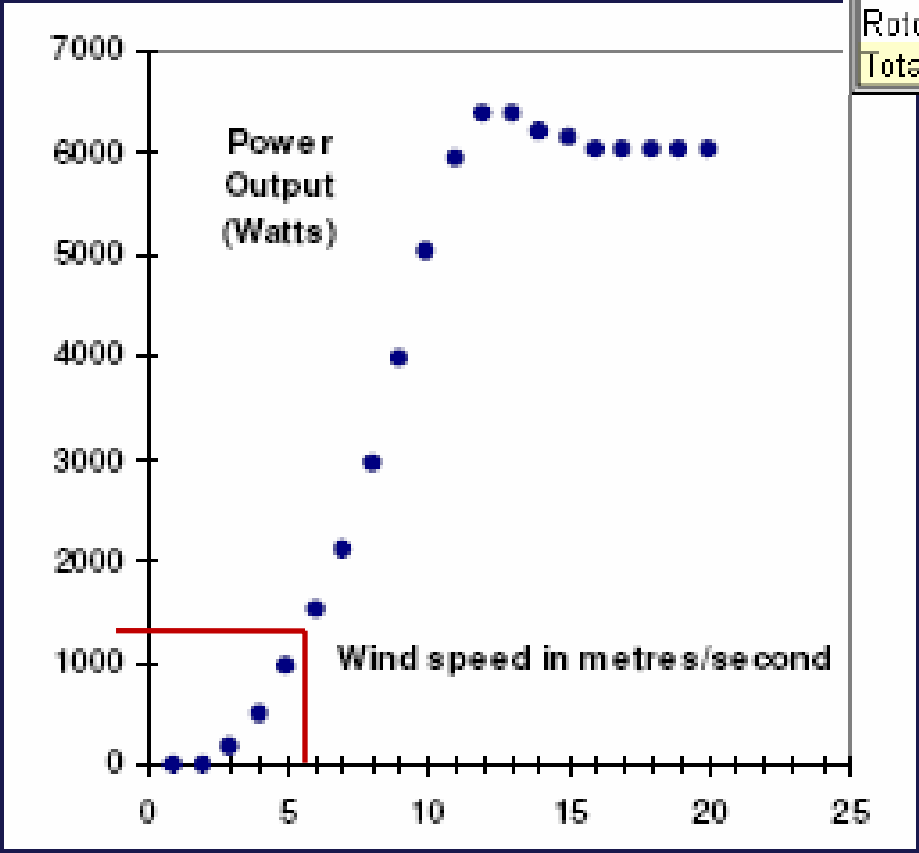
Wind Energy Feasibility

- 70% of total funding eligible to be subsidized by NYSERDA
- Area known for high winds, could be justifiable with state funding
- Wind Map



Wind Energy Feasibility

- PROVEN 6kWTurbine Output



Manufacturer	Proven Energy, Ltd.
Rated Output @ 12.5 m/s	6 kW
Rated Output @ 5.5 m/s (Buffalo, NY)	1 kW
Rotor Diameter	5.5m
Total Weight	860 kg

Wind Energy Feasibility

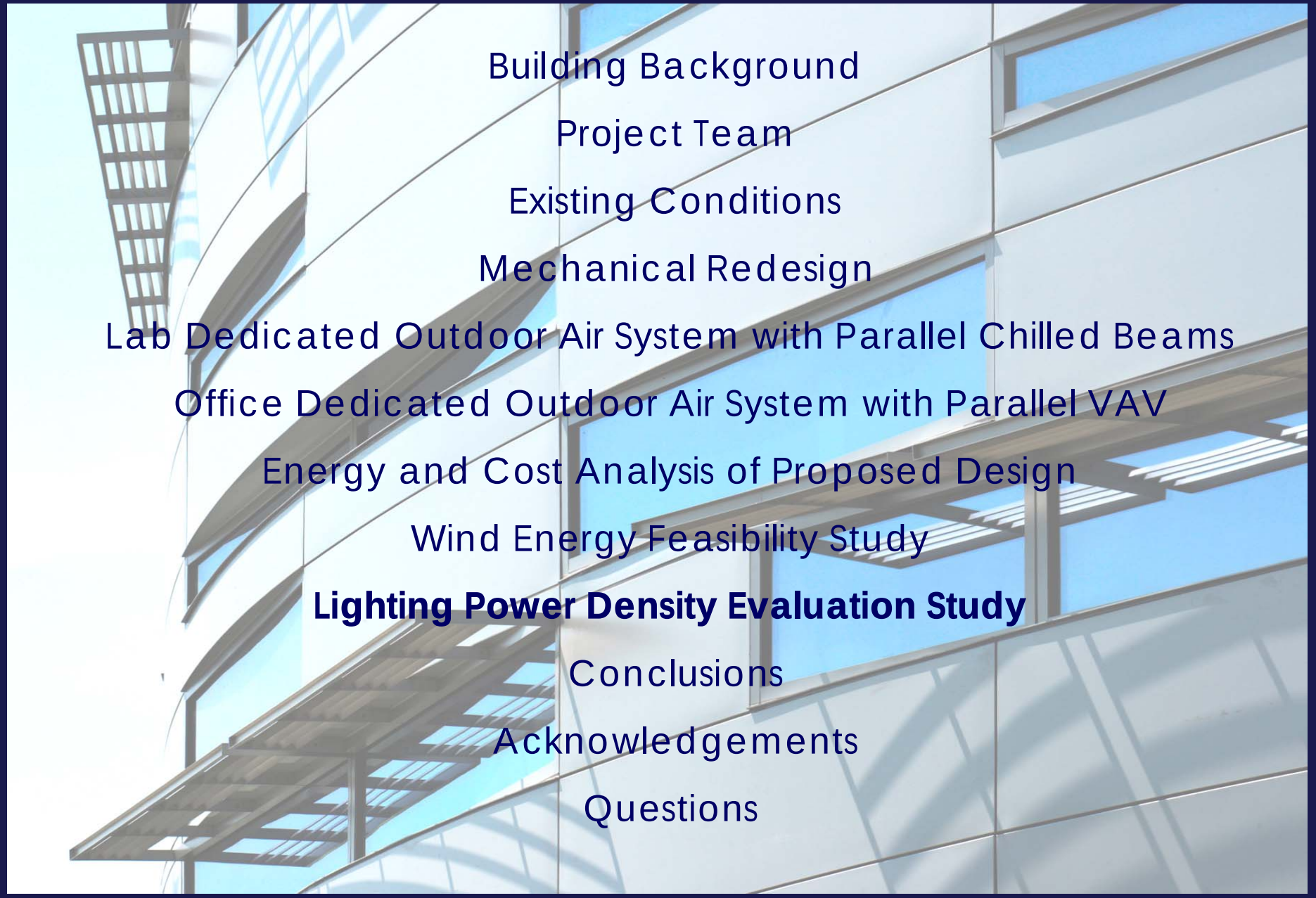
Proven 6kW Wind Turbine w/Grid Connect	$18,160
Isolation and Rectification Controller	$1,090
Tilt-up self-supporting mast (9m)	$6,860
Total Cost per Turbine	$26,110
Total Installed Cost	$52,220
Total Cost with 70% NYSERDA discount	**$15,666**

$$\text{Payback Period (years)} = \frac{\text{Initial Cost}}{\text{Annual Savings}}$$

Assume Annual Savings at Peak Electric Rate:

Annual Savings = 12,000 kWh * $0.0095/kWh = $1,140

$$\text{Payback Period} = \frac{\$15{,}700}{\$1{,}140} = \textbf{14 years} = \textbf{POSSIBLE}$$



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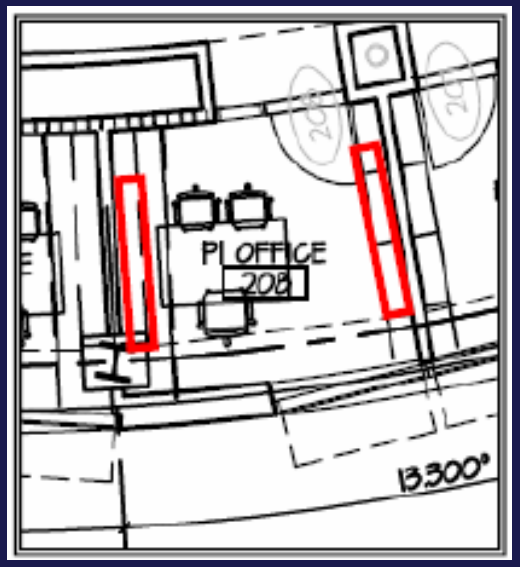
Lighting Concerns

Proposed Scope

- Evaluate typical office lighting
- Retrofit Fixtures without Negative Impact

- 50 Private offices plus general office space



	Lamp	Watts	Length	Lumens (25°C)	2 lamp Fixture
Origional	39W T5	39W	45.2"	3100	78W
Retrofit	28W T5	28W	45.2"	2900	58W

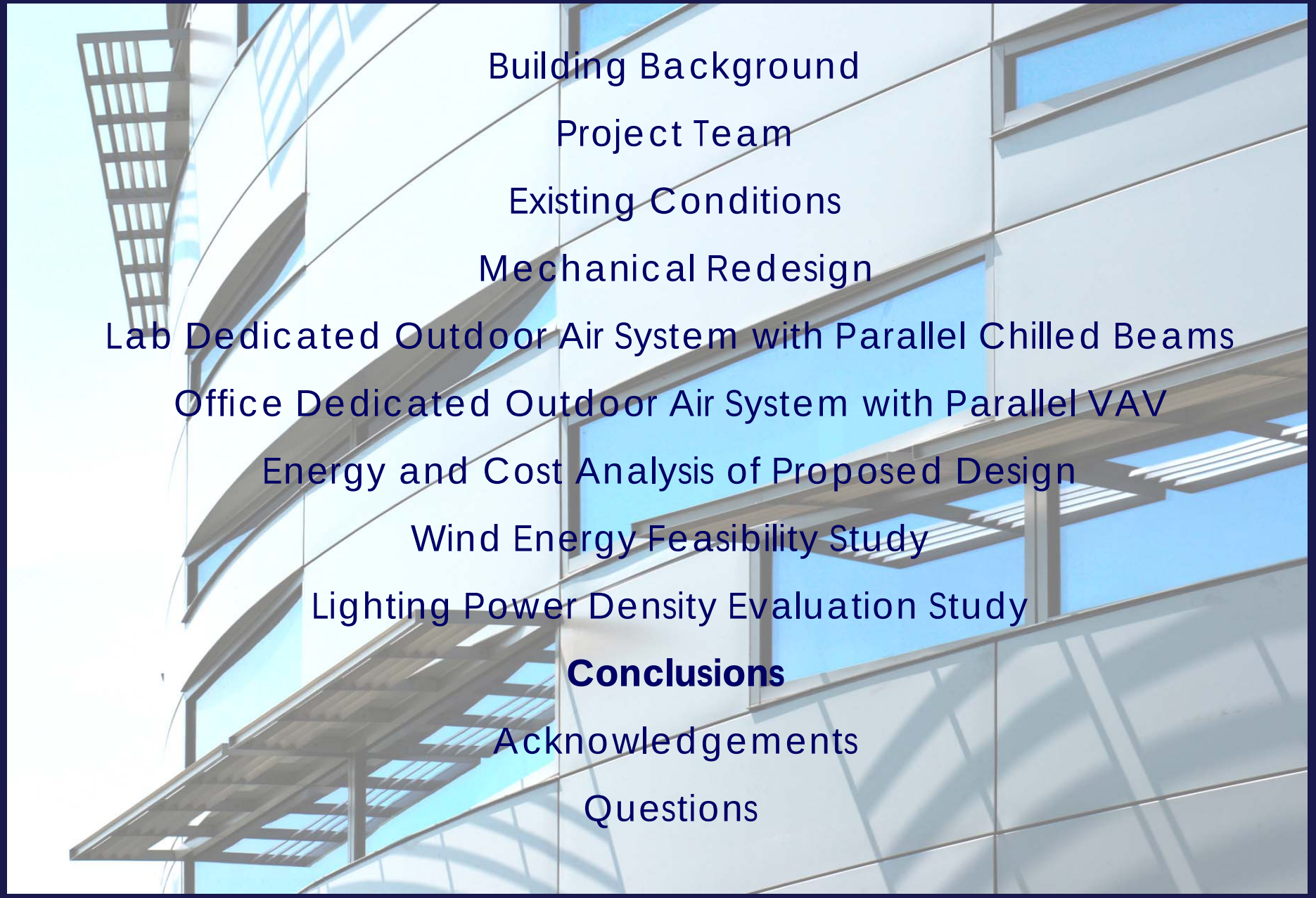
Lighting Concerns

- Redesign implemented while preserving integrity of original design
- Higher initial bulb cost

	W	LPD	Btu/hr
Original	108,040	1.46	368,653
Redesign	97,680	1.32	333,302
Difference			35,351
			2.95 ton

- Reduction in Cooling Load by 2.95 tons
- Reduction in overall LPD from 1.48 W/ft^2 to 1.33 W/ft^2

- **Cost Reduction**
  - Phillips F39T5/841/HO - $9.99
  - Phillips F28W/T5/830 - $8.50
- **Savings** $1.49 x 200bulbs = **$298 initial savings**



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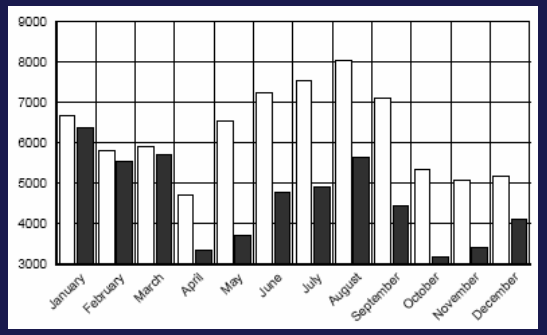
Conclusions and Thoughts

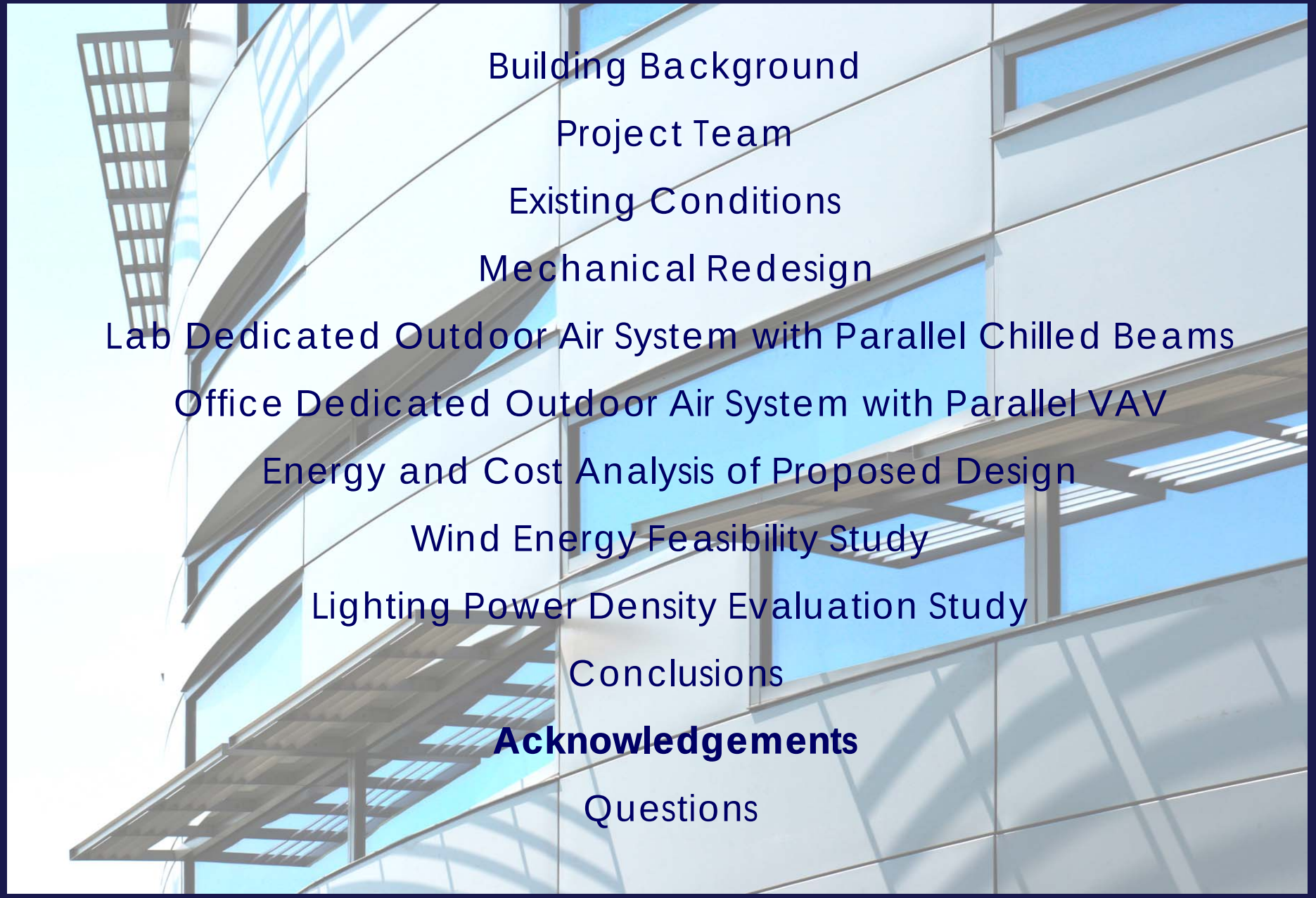
Summary

- Dedicated Outdoor Air Systems to replace DX and 100% OA VAV Units
- **Reduced Electrical Load** by 26% annually
- **Reduced annual utility Costs** by approx $20,000/yr
- **Reduced Initial cost** of mechanical system by $248,173
- **Wind Power** possible, with funding
- **Reduced Lighting Power Density** with reduced-watt bulbs saves energy and first costs



Recommendations

- Redesign considerations a viable alternative to existing design



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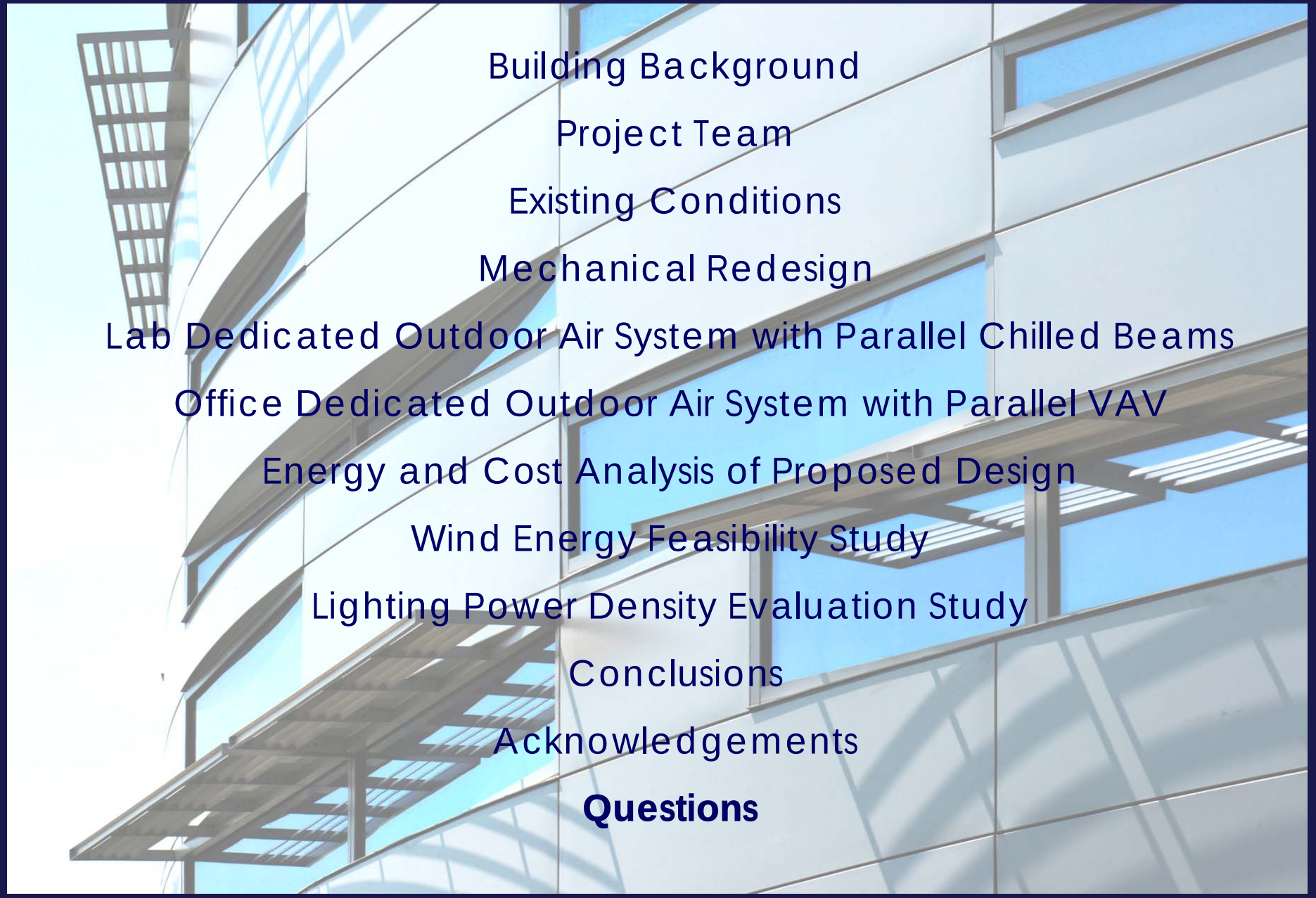
Acknowledgements

- Eric Lindstrom and the rest of the Cannon Design Team
- Walt Pangborn at the Hauptman-Woodward Institute
- All of the AE Faculty, especially Dr. Freihaut
- Friends and Family
- Finally, the AE class of 2007

... we did it!!



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Questions?